CLAIMS

What is claimed is:

1. A method of dry plasma etching a substrate to form at least one laterally-defined recess structure in the substrate, comprising the steps of:

performing a first etching under a first etching condition, the first etching including anisotropically etching the substrate to a first etch depth; and

performing a second etching under a second etching condition, the second etching including semi-anisotropically etching the substrate to a second etch depth, thereby forming the laterally defined recess structure with precise control of lateral undercut.

2. The method of claim 1 wherein the first etching condition comprises a first isotropic etch duration and the second etching condition comprises a second isotropic etch duration, and the method further comprises controlling the lateral undercut by adjusting at least one of the first and second isotropic etch durations during at least one of the first and second performing steps.

3. The method of claim 1 wherein the first etching condition comprises a first isotropic etch duration and the second etching condition comprises a second isotropic etch duration, and the second performing step includes controlling the lateral undercut by adjusting the second isotropic etch duration.

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4. The method of claim 3 wherein the controlling step includes adjusting the second isotropic etch duration to be greater than the first isotropic etch duration.

5. The method of claim 1 wherein the second etching condition comprises a plurality of factors including a gas flow rate, a gas pulse duration, and a bias power, and the second performing step includes controlling the lateral undercut by adjusting at least one of the plurality of factors of the second etching condition.

6. The method of claim 1 further comprising the step of performing a third etching under a third etching condition, the third etching including isotropically etching the substrate to a third etch depth.

7. The method of claim 6 wherein the third etching condition comprises a minimal bias power.

8. The method of claim 6 wherein the third performing step includes isotropically etching the substrate to form at least one undercut section in the substrate.

9. The method of claim 8 wherein the undercut section of the substrate formed during the third performing step comprises at least one micro-machined device.

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10. The method of claim 9 wherein the micro-machined device is selected from a cantilever and an optical mirror.

11. The method of claim 8 wherein the undercut section of the substrate formed during the third performing step comprises at least one on-chip device.

12. The method of claim 11 wherein the on-chip device is selected from an inductor, a capacitor, a transformer, a transistor, and a micro-antenna.

13. The method of claim 1 wherein the first etching condition is the same as the second etching condition with respect to types of gases employed for the etching.

14. The method of claim 13 wherein the types of gases employed include C4F8 and SF6.

15. The method of claim 1 wherein the first etching condition differs from the second etching condition with respect to at least one factor selected from a gas flow rate, a gas pulse duration, a total etch duration, a source power, and a bias power.

16. The method of claim 15 wherein the first etching condition comprises a SF6 gas pulse duration of approximately 10 seconds, and the second etching condition comprises an SF6 gas pulse duration of approximately 30 seconds.

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17. The method of claim 15 wherein the first etching condition comprises a total etch duration of approximately 3 minutes, and the second etching condition comprises a total etch duration of approximately 15 minutes.

18. The method of claim 15 wherein the first etching condition comprises a bias power of approximately 200 volts during an SF6 gas pulse duration, and the second etching condition comprises a bias power of approximately 150 volts during an SF6 pulse duration.

19. The method of claim 1 wherein the first performing step includes anisotropically etching the substrate through a patterned masking layer, and the second performing step includes semi-anisotropically etching the substrate through the patterned masking layer.

20. The method of claim 19 wherein the patterned masking layer employed in the first and second performing steps comprises one or more layers selected from photoresist, polyimide, metal, and oxide.

21. A method of fabricating a device suspended on a substrate, comprising the steps of:

forming the device on the substrate; and

forming a cavity underneath the device to suspend the device on the substrate,

wherein the second forming step comprises

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performing a first etching under a first etching condition, the first etching including anisotropically etching the substrate through a patterned masking layer to a first etch depth; and

performing a second etching under a second etching condition, the second etching including semi-anisotropically etching the substrate through the patterned masking layer to a second etch depth, thereby forming the cavity underneath at least a portion of the device with precise control of lateral undercut.

22. The method of claim 21 wherein the first etching condition comprises a first isotropic etch duration and the second etching condition comprises a second isotropic etch duration, and the method further comprises controlling the lateral undercut by adjusting at least one of the first and second isotropic etch durations during at least one of the first and second performing steps.

23. The method of claim 21 wherein the first etching condition comprises a first isotropic etch duration and the second etching condition comprises a second isotropic etch duration, and the second performing step includes controlling the lateral undercut by adjusting the second isotropic etch duration.

24. The method of claim 23 wherein the controlling step includes adjusting the second isotropic etch duration to be greater than the first isotropic etch duration.

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25. The method of claim 21 wherein the second etching condition comprises a plurality of factors including a gas flow rate, a gas pulse duration, and a bias power, and the second performing step includes controlling the lateral undercut by adjusting at least one of the plurality of factors of the second etching condition.

26. The method of claim 21 further comprising the step of performing a third etching under a third etching condition, the third etching including isotropically etching the substrate through the patterned masking layer to a third etch depth to form the cavity by laterally undercutting the device.

27. The method of claim 26 wherein the device laterally undercut during the third performing step comprises at least one micro-machined device.

28. The method of claim 27 wherein the micro-machined device is selected from a cantilever and an optical mirror.

29. The method of claim 26 wherein the device laterally undercut during the third performing step comprises at least one on-chip device.

30. The method of claim 29 wherein the on-chip device is selected from an inductor, a capacitor, a transformer, a transistor, and a micro-antenna.

31. The method of claim 21 wherein the patterned masking layer employed in the first and second performing steps comprises one or more layers selected from photoresist, polyimide, metal, and oxide.

32. A method of dry plasma etching a substrate to form at least one trench in the substrate, comprising the steps of:

performing a first etching using an anisotropic etching agent and an isotropic etching agent to etch the substrate to a first etch depth, the first etching including alternately pulsing the anisotropic etching agent and the isotropic etching agent at respective first pulse durations; and

performing a second etching using the anisotropic etching agent and the isotropic etching agent to etch the substrate to a second etch depth and form a re-entrant shape in the trench with approximately zero lateral undercut, the second etching including alternately pulsing the anisotropic etching agent and the isotropic etching agent at respective second pulse durations,

wherein the second pulse duration of the isotropic etching agent is greater than the first pulse duration of the isotropic etching agent.

33. The method of claim 32 wherein the first and second pulse durations of the anisotropic etching agent are the same.

34. The method of claim 32 wherein the anisotropic etching agent comprises C4F8 gas and the isotropic etching agent comprises SF6 gas.

35. The method of claim 34 wherein the first and second pulse durations of the C4F8 gas are approximately equal to 3 seconds.

36. The method of claim 34 wherein the first pulse duration of the SF6 gas is approximately equal to 10 seconds, and the second pulse duration of the SF6 gas is approximately equal to 30 seconds.

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